Nordic Seaweed Conference: Meeting the UN sustainability goals by innovation in macroalgae

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9TH NORDIC SEAWEED CONFERENCE

MEETING THE UN SUSTAINABILITY GOALS BY INNOVATION IN MACROALGAE

AlgeCenter Danmark

ABSTRACT BOOK

9th and 10th of October 2019
Kystvejens Hotel and Konferencecenter
Grenaa, Denmark

ALGECENTER DANMARK IS:
- Aarhus University
- Danish Teknological Institute
- The Kattegatcenter

WE WORK WITH:
- Circular Bioeconomy
- Green solutions
- Research
- Business development
- Dissemination

WE FOCUS ON CULTIVATION AND USE OF MACROALGAE FOR:
- Food
- Feed
- Energy
- Plant health & fertilisers
- Ingredients
- Bioactive components
- Biomitigation of nutrients and CO_2
- Materials
- Art

WE FOCUS ON THE ENTIRE VALUE CHAIN:
- Cultivation & cultivation technology
- Pre-treatment & processing
- Product development
- Legislation

ALGECENTER DANMARK FACTS:
- Established in 2010
- Active industrial network
- Laboratories in Aarhus, Silkeborg, Taastrup and Sdr. Stenderup
- 12 cultivation tanks at Grenaa Harbour
- Twenty hectare off-shore cultivation site in the ocean near Djursland
- Annual international conference in Grenaa: Nordic Seaweed Conference – Macroalgae from research to Industry
- National and international research and development projects ranging from small projects to large EU projects
- Collaboration with industrial partners ranging from SMEs to large industries, education and research institutions

Frontpage photo: Lone Thybo Mouritsen

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AARHUS UNIVERSITY

AlgeCenter Danmark

Programme Wednesday 9th October:

10.00 - 11.00	Registration	Chair:
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14.45 - 15.05	Gizaw Satessa, University of Copenhagen: Effect of seaweed products on weaner pig productivity and gut development	
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TWEET: #NSC19

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09.40 - 10.10	Ole G Mouritsen, University of Copenhagen: Umamification of vegetables by macroalgae for eating more green	
10.10 - 10.30	Cecilie W Nielsen, DTU, Denmark Is blanching the solution for lowering iodine in sugar kelp and which quality consequences does it have to blanch sugar kelp?	
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13.05 - 13.30	Susse Wegeberg, Aarhus University, Denmark The unknown kelp forests of Greenland – the East coast's unexpected lushness	
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TWEET: #NSC19

ABSTRACT #1

INNOVATIONS IN THE SUSTAINABLE SEAWEED PROCESSING TECHNOLOGIES FOR FOOD AND FOOD INGREDIENTS

SPEAKER

Balunkeswar (Balu) Nayak, Ph.D.
Associate Professor of Food Processing, School of Food & Agriculture, University of Maine, Orono, United States.

Dr. Balu Nayak received his Ph.D. in Food Engineering from Washington State University, Pullman, WA, USA. He has more than 16 years of experience on the food process engineering and applications on the safety, quality and functionality of health benefitting compounds in agricultural and aquaculture commodities.

Dr. Nayak has been extensively investigating the development of sustainable process and product approaches for high-value added aquaculture seaweed products. He is the director of Food Processing and Engineering Laboratory in the School of Food and Agriculture and advises many post-doctoral, graduate and undergraduate students.

As an expert in sustainable food processing and engineering, he has presented at many international professional conferences as invited and keynote speaker. Dr. Nayak has published his research in many reputed journals and is a scientific editor for the Journal of Food Processing and Technology and Trends in Post-harvest Technology.

Sustainable seaweed processing needs to address feasibilities in the economic and environmental factors, and careful considerations specific to the industry. While the United Nations Sustainability guidelines clearly highlights the long-term benefits for human being, understanding and execution of sustainable factors could be quite challenging for commodities such as seaweed that are localized or emerging as superfoods.

Sustainable growth of farmed seaweed needs market segments that can tap high quality and safe food products. Like high moisture land-based crops, fresh seaweeds are perishable and have limited shelf-life. Preservation of seaweeds is needed to improve their shelf-life, which directly provides opportunities to develop new food and value-added products. One important preservation technique is to remove moisture from the seaweeds, to prepare low moisture products by drying or dehydrating seaweed. However, drying energy-intensive, and is highly dependent on several factors i.e. drying temperature, moisture diffusion, material thickness, surface area and phase transition (from glassy to rubbery state). Sustainable drying conditions are required to efficiently remove moisture from the seaweed cell matrices without damaging much of their intrinsic properties i.e. retaining bioactive compounds and valuable nutrients to make safe and high quality products.

Innovations in seaweed processing and adaptation of by the industry is the key to successfully implement these sustainability goals. This presentation will highlight innovations in seaweed processing technologies for developing future food and food ingredients for the sustainable growth of the industry.

ABSTRACT #2

FUTURE SUSTAINABLE SEAWEED INDUSTRIES IN EUROPE - SOCIAL ASPECTS AND THE NEED FOR PUBLIC DIALOGUES

SPEAKER

Rita Clancy
EURIDA Research Management, Germany.

Rita is the owner of EURIDA Research Management, a communication agency that she founded in 2012 and that specialises in developing and implementing tailored dissemination, communication and public engagement strategies for research and innovation. Her communication concepts follow innovative approaches in Science Communication built upon two-way communication and dialogues, for example with citizens and policy-makers.

Currently, Rita is Dissemination Officer and as such responsible for dissemination, communication and public engagement activities in the Horizon 2020 'MacroFuels' and the BBI JU 'UNRAVEL' projects. Rita is a scientist at heart and holds degrees in Isotope Geochemistry and Communication Sciences.

Macroalgae receive growing attention as sustainable biomass for high-value industries in the sectors of food, feed, pharmaceuticals, biomaterials or biofuels. The seaweed industry in Europe is still in its infancy. To establish a sustainable seaweed industry in Europe, a multitude of social impacts, potentially positive and negative, have to be considered. Strategies to maximise societal benefits and to minimise possible social risks are needed. Furthermore wide public acceptance towards a seaweed industry in Europe will be vital. This includes novel seaweed-based products as well as industry-scale production processes. So far both, social impacts and public perception towards seaweed are assumed to be widely positive due to the perceived potential for a sustainable bio-based economy and the 'green', environmentally benign reputation of the biomass.

However, very few studies have been conducted to provide systematic insights into the social impacts of large scale seaweed production and the sustainability of seaweed-based products. The same applies to public attitudes towards seaweed. Results retrieved in the 'MacroFuels' project revealed that social impacts and public perception are equally scale-dependent and that there are uncertainties and remining knowledge gaps that come with upscaling processes, especially in terms of environmental risks and changes to coastal communities due to economic development and industrialisation. They furthermore confirmed that public support increases with awareness levels, environmental benefits and perceived economic opportunities, as indicated by a recent study from Sweden. Even more importantly, dialogues provided 'MacroFuels' experts with outside-in perspectives and valuable knowledge on local environments and economic opportunities. Such insights resulting from public dialogue represent great future opportunities for all actors along seaweed value chains to maximise social impacts and avoid unnecessary risks.

ABSTRACT #3

SEAWEED CULTIVATION AND PROCESSING FOR SUSTAINABLE PRODUCTION OF FOOD AND OTHER PRODUCTS

SPEAKER
David Aldridge
Seaweed Energy Solutions, Norway

David Aldridge is a hatchery technician at SES and has worked at the company since 2017. David has and Msci. in Marine Biology from The University of Southampton (UK) and a Ph.D. in phytoplankton ecology from the Graduate School of the National Oceanography Centre, Southampton.

More than 30 million tons of seaweed are produced annually, of which >95% originates from cultivation in Asia. 87% of all seaweeds are used for human consumption, either directly or as food additives. The European market is dominated by Asian products, but there is an increasing interest in seaweed of local origin, with focus on traceability, sustainability and organic certification.

Seaweed Energy Solutions AS (SES) was founded in 2009 and is a pioneer of seaweed cultivation in Europe. SES focuses on sustainable seaweed cultivation, mainly for the food market, but also other mid-high value markets like feed, biochemicals etc. SES is located in Norway, where the company owns and operates its own hatchery in Trondheim and has 65 ha of sea concession at Frøya, with an annual capacity for producing more than 1000 tons seaweed.

Since 2014, SES has cultivated Saccharina latissima and Alaria esculenta at pilot scale (50-100 tons annually). The production is certified organic by Debio and is focused on sustainable production of high-quality seaweed. SES manages the whole seaweed production cycle, from hatchery stage with in-house seedling production, to cultivation at sea and processing. The seaweed is processed locally at Europe's largest crab factory, Hitramat. For seaweed to become a mainstream food in Europe, innovations in processing and product development are required to improve taste, texture, nutritional value and food safety. Processing is one of SES' core areas, and the company collaborates with R&D institutes and customers to develop optimal processing for food innovations.

ABSTRACT #4

UV-SCREENING IN BALTIC SEAWEEDS AND ITS APPLICATION IN COSMETIC PRODUCTS

SPEAKER

Rafael Meichssner
Christian-Albrechts-University Kiel, Germany

2011-2014: Bachelor Biology at Christian-Albrechts-University Kiel

2014-2017: Master Biological Oceanography at Christian-Albrechts-University and Geomar Helmholtz Centre for Ocean Research Kiel

Since 2017: PhD-project on cultivation of Fucus-species in the Baltic Sea, their UV-light protection and their utilization in cosmetic products; at Christian-Albrechts-University Kiel in cooperation with CRM (Coastal Research & Management) and OceanBASIS GmbH

In recent years the search for environmentally friendly sun care products has intensified due to potentially harmful effects of classic UV-filters like oxybenzone and TiO2 to the marine environment.

Among others, seaweeds have been discussed as an alternative source for UV-screening compounds. In this context a common narrative among seaweed scientists and entrepreneurs states that seaweed species which are well protected from UV-radiation contain high amounts of UV-absorbing compounds (e.g. phlorotannins, mycosporine-like amino acids, etc.) which in turn can be extracted from these seaweeds for the fabrication of sun care products.

However, there are a number of assumptions in this narrative which are not necessarily true. Therefore, we investigated the following questions in the "SunTec"-project, financed by the Land Schleswig-Holstein: How can UV-protection be measured in vivo in Baltic green and brown seaweeds (Cladophora sp., Fucus sp.)? Can in vivo UV-protection be correlated to the content of UV-absorbing compounds in the thallus? Can extracts of these compounds exert UV-absorbing activity sufficient for sun care products? Which light protection factors can be achieved using these extracts?

In order to answer these questions, several methods have been applied and refined, involving a method using chlorophyll fluorescence for the rapid determination of in vivo UV- screening in green and brown seaweeds. Based on the results of this project further developments in the "seaweed for sun care" field are discussed.

CO-AUTHORS

Rafael Meichssner[1,4], Frauke Pescheck[2], Inez Linke[3], Christian Koch[3,4], Opayi Mudimu[1], Rüdiger Schulz[1], Wolfgang Bilger[2]

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ABSTRACT #5

EFFECT OF SEAWEED PRODUCTS ON WEANER PIG PRODUCTIVITY AND GUT DEVELOPMENT

SPEAKER

Gizaw Satessa

Copenhagen University Department of Veterinary and Animal Sciences, Denmark

Three separate trials were conducted to assess the impact of seaweed products alone or in combination with fermented rapeseed as well as some other potential alternatives to medicinal ZnO on piglet performance and gut development. In all the experiments, two controls (negative controls – unsupplemented; positive controls – supplemented 2500 ppm ZnO) were considered to compare the effects of the tested products. The first experiment was done with SEGES and involved feeding of a commercial product of macroalgae (Oceanfeed swine, OFS) as well as other products (1500 ppm ZnO, GærPlus and Miya-Gold). OFS demonstrated no effect on performance but inhibited gut development in weaned piglets. The second experiment was a pilot study in Poland where weaned piglets were supplemented with increasing doses of fermented rapeseed (8%, 10%, 12%,15% and 25%) as well as 10% fermented rapeseed mixed with 0.6% Ascophyllum nodosum (0.6%FRMA) or mixed with 1% Ascophyllum nodosum (1% FRMA).

At both doses, the mix sustained similar weight gains compared to the positive control and increased the percentage of piglets that completed the experiment (90%) at 0.6% inclusion showed no effect on the diarrhea. The third experiment was a continuation of the pilot trial, but larger, using rapeseed fermented alone (FRM) or co-fermented with the brown macrolagae Ascophyllum nodosum (FRMA) or combination of Ascophyllum nodosum and Saccharina latissima (FRMAS). FRM was overall superior. FRMA increased piglet performance and improved gut microbiota but inhibited colon development whereas FRMAS reduced performance, but enhanced jejunum development and gut microbiota. In conclusion, seaweed products tested did not demonstrate consistent effect on the performance and gut development and hence its potential as replacement for medicinal ZnO in weaned piglet may not be not promising.

CO-AUTHORS

Hanne Helene Hansen[1,] Rajan Dhakal[1], Morteza Mansouryar[1,] Søren Kjærulff[3], Paulina Tamez[3],Julie Krogsdahl Bache[2], Niels Jørgen Kjeldsen[2] and Mette Olaf Nielsen[1]

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ABSTRACT #6

POTENTIAL OF LOCAL SEAWEED TO IMPROVE GROWTH PERFORMANCE IN PIGLETS

SPEAKER

Marleen van der Heide
Department of Animal Science, Aarhus University, Denmark

Marleen van der Heide has started her PhD at the department of Animal Science (Aarhus University, Foulum) in 2018. She works within the animal nutrition and physiology field. Her PhD focusses on finding added value of novel feedstuff such as seaweed, insect and mussel meal, for monogastric animals.

The current abstract is part of a greater seaweed project, TANG.nu. The same seaweeds were used to perform a similar study in calves. At the 2020 Nordic Seaweed Conference Milani Bhagya Samarasinghe and Lorenzo E. Hernández Castellano will present the results about feeding calves with seaweeds.

It was hypothesized that bioactive compounds in seaweed could improve gut health and reduce pathogens in piglets, thereby improving growth by diarrhea reduction comparable to zinc.

During two periods, ninety 28-day old weaned piglets (7.2 ± 0.9 kg) were housed individually in three similar rooms. A low hygiene environment was created by spreading equal amounts of grower pigs' feces in each pen. Piglets were assigned to one of five treatments: negative control, NC+zinc, NC+5% as fed Ulva Lactuca, NC+5% as fed Ascophyllum Nodosum or NC+5% as fed Saccharina Latissima. Feed intake and weight gain were recorded weekly. Pigs were slaughtered after 14 days in experiment. Digesta pH from stomach, small intestine and colon, and intestinal length were measured. The statistical model was a mixed one-way anova with treatment as fixed effect, initial weight as covariate, and period and room as random effects (lme4 package R). No significant differences were found between treatments for the above mentioned parameters (P>0.05).

The current results cannot support the hypothesis of improved animal performance because of high variation among piglets within the dietary treatments. Notably, zinc supplementation did not improve growth. Seaweed volume limited the number of replicates. Upcoming results on microbiota and volatile fatty acids in the digesta as well as data on intestinal morphology may elucidate effects on gut health.

CO-AUTHORS

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ABSTRACT #7

WHAT IS THE POTENTIAL DIGESTIBILITY AND METHANE REDUCTION OF SEAWEED AND SEAWEED PRODUCTS FOR CATTLE?

SPEAKER

Hanne Helene Hansen
University of Copenhagen, Denmark
Associate professor in Department of Veterinary and Animal Sciences

In order to assess the potential for methane reduction and digestibility, seaweed and seaweed products were tested at the UCPH fiber degradation and gas production laboratory. Alaria esculenta, Ascophyllum nodossum, Saccharina lattisima and Fucus serratus were tested as intact, freeze dried seaweed. Extracts from S. latissima and Fucellaria lumbricalis, and fucoidan and alginate were tested. Additionally, a commercial product containing an unknown mix of seaweeds was tested.

All samples were tested in comparison to typical cattle feeds. Without significantly decreasing degradation, a consistent methane reduction of roughly 20% was observed from A. esculenta, A.nodossum and the commercial product, while degradation increased when using S. latissima and S. latissima extracts. However, degradation of total dry matter was greatly influenced by the large variation in organic matter content.

CO-AUTHORS

Morteza Mansouryar, Rajan Dhakal, Gizaw Dabessa Satessa and Mette Olaf Nielsen
University of Copenhagen, Faculty of Health and Sciences, Department of Veterinary and Animal Sciences.

ABSTRACT #8

SEAFARM ALGAE CULTIVATION FOR A MORE SUSTAINABLE WORLD

SPEAKER

Frederik Gröndahl
Royal Institute of Technology, Sweden

Associate Professor Fredrik Gröndahl is currently running several projects related to algae cultivation and biorefineries and he is the project leader for e.g. Seafarm (www.seafarm.se), Kelpi and the EU project GRASS.

He has a background in marine science e.g. marine biology and oceanography. He is also working with sustainability and education and is the author of several text books on that subject. He is also one of the six co-funders of the first Swedish company for commercial kelp production "KosterAlg AB" (www.kosteralg.se)

Kelp farming circumvents several disadvantages related to land-based biomass production, e.g. the need for fertilizers and irrigation, and does not compete for valuable arable land. In addition, seaweeds grow fast and their farming counteracts coastal eutrophication, stimulate biodiversity and may even be an important carbon sink. The overreaching goal of the SEAFARM project (www.seafarm.se) was to develop a sustainable system for the use of seaweeds/kelp as a renewable resource in a future bio-based industry for the Swedish society. The trans- disciplinary research approach included techniques for cultivating seaweeds to be used as raw material in a biorefinery for the production of food, feed, bio-based materials and bioenergy.

A holistic approach was used where utilization of the resource is maximized in each step of the process cycle. The seaweeds/kelp are cultivated at the Swedish west coast and methods suitable for preservation and storage was evaluated. The obtained biomass was fractionated in an integrated biorefinery. The different fractions were thoroughly characterized and recovered for production of biochemical, polymers, and food/feed additives. The residues from the biorefinery was utilized for production of biogas and biofertilizers. In parallel, a general multi-process sustainable assessment method was developed to analyse the overall sustainability of the system.

The multi-disciplinary research team collaborated closely with a set of state agencies, commercial enterprises and other stakeholders in the different tasks of the project. The study presented here will summarise the results from the successful five-year project and how the SEAFARM project have boosted the development of a growing new biobased industry in Sweden, that will be an important part of the development of a truly sustainable society.

ABSTRACT #9

OPERATIONALISING UN SUSTAINABLE DEVELOPMENT GOALS FOR ALGAE-BASED PROCESS DEVELOPMENT VIA INTEGRATED LIFE CYCLE SUSTAINABILITY ASSESSMENT

SPEAKER

Heiko Keller
ifeu – Institute for Energy and Environmental Research Heidelberg, Germany

Dr Heiko Keller is senior project manager at ifeu – Institute for Energy and Environmental Research Heidelberg, Germany. He is a biochemist / biophysicist by education. His main working fields are life cycle assessment (LCA) and integrated life cycle sustainability assessment (ILCSA) of bio-based systems.

In the past 10 years, Heiko was and is involved in numerous projects on national and EU level and led/is leading work packages on integrated sustainability assessment in several EU projects. This includes projects on the cultivation of algae in various systems and their processing in a biorefinery approach for a variety of products including nutraceuticals, feed, biochemicals and biofuel. He has authored numerous publications and is a reviewer for international scientific journals. He is a visiting lecturer for LCA at Karlsruhe Institute of Technology (KIT).

UN sustainable development goals (UN-SDG) follow a comprehensive top-down approach and were designed for governmental and non-governmental organisations on a national and international level. However, it is not trivial for e.g. a company to find out which impacts a concrete product, process or decision may have on the UN-SDG and how they could be improved. One limitation is that many aspects covered by UN-SDG are not routinely assessed on a product level and another is that this level has to be connected to the (inter)national level.

Following a bottom-up approach on a product level, sustainability is often assessed by. (environmental) life cycle assessment (LCA) and related methodologies. LCA was extended by life cycle costing (LCC) and social life cycle assessment (sLCA) into life cycle sustainability assessment (LCSA). In particular for prospective assessments of biomass-related products, LCSA has important limitations because impacts on e.g. local environment, nutritional health aspects and safety are not covered. The knowledge on these impacts is often available via other

ABSTRACT #10

HEALTH BENEFITS AND USES OF SEAWEED AND HOW THIS HAS CHANGED OVER THE LAST 20 YEARS IN EUROPE

SPEAKER

Prannie Rhatigan, Ireland

Prannie Rhatigan is a medical doctor with a lifetime experience of harvesting and cooking organically with seaweed vegetables. Born and raised in the North West of Ireland where she still lives, her lifelong interest in the connections between food and health prompted her to publish the Irish Seaweed Kitchen in 2009.

As an experienced General Practitioner she now works mainly in Public Health Medicine.

Prannie's position as Ireland's leading culinary seaweed expert continues to consolidate with workshops, lectures, talks and seaweed cookery demos stretching across the globe. She founded Sligo Seaweed Days, looks forward to a yearly excursion with The Coney Island Experience.

In 2019 her cookbook Irish Seaweed Christmas Kitchen came first in the Gourmand Best in the World awards in the seafood category.

Health benefits and uses of seaweed and how this has changed over the last 20 years in Europe

Seaweed research in the form of the health benefits of digesting seaweed continues in areas such as anti -inflammation, anti -obesity and anti -tumour activity. The microbiome of the colon is an area of medicine continuing to attract attention.

The current research indicates brown seaweed in particular, in a healthy colon, can be fermented; and fucoidan, alginate and laminarin (beta glucan) can each feed good bacteria and even shift the relative abundance of the major bacteria groups by helping to increase Bacteroidetes (associated with leanness) and helping to decrease Firmicutes (associated with increased weight). Bifidobacterium in particular is increased. This is associated with increased short chain fatty acid production, which favourably feeds and protects the cells lining the colon.

The most benefits are gained by those with a healthy microbiome but even among the less healthy, dietary seaweed appears to offer benefits.

ABSTRACT#11

UMAMIFICATION OF VEGETABLES BY MACROALGAE FOR EATING MORE GREEN

SPEAKER

Ole G. Mouritsen
Department of Food Science
Taste for Life
University of Copenhagen, Denmark

Ole G. Mouritsen, PhD DSc, is a physicist and professor of gastrophysics and culinary food innovation at the University of Copenhagen.

He has a background in physical chemistry, interfacial science, and membrane biophysics. He is the author of several scientific books and about 400 scientific papers and reports, in addition to being recipient of a number of prestigious science and science communication prizes.

He is appointed Japanese Cuisine Goodwill Ambassador by the Japanese Ministry of Agriculture, Forestry, and Fisheries. He is currently president of the Danish Gastronomical Academy and director of the Danish national research- and communication center Taste for Life.

In his spare time, he cooks, collaborates with chefs, furthers his knowledge of all aspects of food, and writes articles and books about the science of food and taste. Currently he works on projects involving the gastrophysics of umami, foods from seaweeds and cephalopods, as well vegetables.

According to the recent report by the EAT-Lancet Commission the world food systems have urgently to be changed globally in order to be able to feed 10 billion people a sustainable, nutritious, and healthy diet by 2050 [1]. The recommendations involve eating more plant-based food, including a daily intake of 500g vegetables and fruit. The question is: can we eat that much? And is it tasty enough? This is were macroalgae and lessons about the unique umami taste from some seaweeds come in [2,3]. Facing the challenge of eating more green, I will describe some aspects of the flavour and texture of seaweeds, including health perspectives and new knowledge about the interaction of seaweeds with our microbiome [4]. Some mention of the importance of science communication will also be touched upon [5].

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4. A mini-review on the microbial continuum: consideration of a link between judicious consumption of a varied diet of macroalgae and human health and nutrition (M. L. Cornish, O. G. Mouritsen, and A. T. Critchley) J. Oceanol. Limnol. 37, 790-805 (2019).

5. Science education and public understanding of science via food, cooking and flavour (P. M. Sörensen and O.G. Mouritsen) Int. J. Gast. Food. Sci. 15, 36-47 (2019).

ABSTRACT #12

IS BLANCHING THE SOLUTION FOR LOWERING IODINE IN SUGAR KELP AND WHICH QUALITY CONSEQUENCES DOES IT HAVE TO BLANCH SUGAR KELP?

SPEAKER

Cecilie Wirenfeldt Nielsen
PhD student at the Danish National Food Institute, DTU and Norwegian University of Science and Technology

Cecilie Wirenfeldt Nielsen is an aquatic food engineer from DTU and NTNU, and has worked with seaweed as foods during her studies. She has mainly worked with Saccharina latissima and has studied the seasonal variation of its amino acid profile and the influence of drying on antioxidants. She is now continuing to specialize in seaweed food processing as a double degree PhD student at DTU and NTNU.

The brown seaweed *Saccharina latissima* (sugar kelp) contains high levels of iodine, which in excess intake can cause adverse human health effects. Cultivated sugar kelp from Seaweed Energy Solutions were undergoing steam and water blanching to attempt reduction of iodine content to ensure a safer food product. Moreover, blanching of sugar kelp might have consequences on the quality in terms of the chemical composition.

To test this, newly harvested sugar kelp was undergoing blanching. The experiment focused on the process variables; time and temperature. The temperatures were between 30 to 100°C and processing time between 0 to 5 minutes. Water blanching was efficient to reduce iodine and lowered the content below the unofficial French threshold value of 2,000 mg iodine per kg dry weight, although around 350 mg iodine per kg dry weight was the reduction going towards a constant level.

The blanched sugerkelp was analyzed for its composition of; water, protein, total fat, and ash to evaluate their loss during blanching. The water blanching at the tested process variables affected water, ash and calculated carbohydrates, but not total fat or protein concentration significantly. Amino acid profile, lipid profile, fucoxanthin and antioxidant capacities are quality parameters to be analyzed.

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ABSTRACT #13

SILAGE FERMENTATION PROPERTIES OF *SACCHARINA LATISSIMA* AND *ALARIA ESCULENTA* UNDER VARIOUS ADDITIVES AND PROCESSING METHODS

SPEAKER

Ying Yen
Faculty of Biosciences and Aquaculture, Nord University, Norway

Ying Yen is a PhD student at the Faculty of Aquaculture and Biology in Nord University, Norway. With a master degree in animal nutrition (Wageningen UR), she is passionate in making seaweed a viable and novel feed ingredient.

Ensiling, a common practice for forage conservation, is a low energy input method to preserve seaweed compared to drying or freezing.

The study aims to investigate the ensiling properties of two brown seaweed species farmed by Lofoten Blue Harvest in Austre Vågan in the Lofoten Islands in Norway (N68, E15): Saccharina latissima (S.L.) and Alaria esculenta (A.E.). The seaweed was harvested in June 2018 and processed within 24 hours at Nord University's Research Station in Bodø. Ensiling treatments followed a 4 X 2 X 2 factorial design using four types of ensiling additives (no additives (CON, control), 0.4% formic acid (FA), homofermentative lactic acid bacterial inoculum, and a mixture of homo- and heterofermentative lactic acid bacterial inoculum), two drying methods (fresh and prewilted to 30% dry matter), and two chopping size (rough and fine). The seaweeds were washed, processed, ensiled in 1 kg vacuum bags in triplicates, and stored at 16°C for three months.

The result confirmed that S. latissima and A. esculenta are ensilable. The silage pH was affected by the use of additives ($P<0.01$), with CON being the highest (S.L.: 5.13, A.E.: 4.76) and FA being the lowest (S.L.: 3.54, A.E.: 3.62). Acetate was the main fermentation product in all treatments, with the lower value in the prewilted samples (S.L.: 8.99 g/kg DM, A.E.: 7.74 g/kg DM) compared to the fresh (S.L.: 28.1 g/kg DM, A.E.: 22.7 g/kg DM) ($P<0.01$). Bacterial inoculants significantly increased the lactate content ($P<0.01$).

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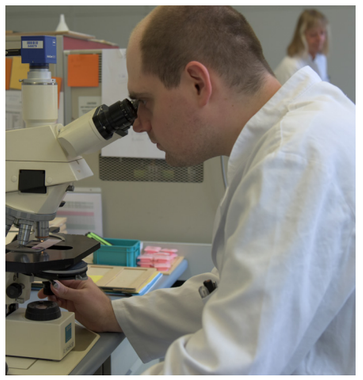
ABSTRACT #14

FUCOIDANS WITH BENEFICIAL EFFECTS FOR OCULAR DISEASES, INFLUENCE ON CELL VIABILITY, VEGF SECRETION AND OXIDATIVE STRESS PROTECTION



SPEAKER

Philipp Dörschmann
University of Kiel, University Medical Center, Department of Ophthalmology, Denmark

Bachelor of Science in Biotechnology and Bioinformatics from the University of Applied Science Mittweida,2013 and finished the master program Pharmaceutical Biotechnology at the University of Applied Science Jena in 2016. Currently, he works as a scientist at the Research Unit of the Ophthalmology Department at the University of Kiel for the project FucoSan, supported by EU InterReg-Deutschland-Denmark and the European Fond of Regional Development.

Background: One of the sustainability goals is health and well-being. Fucoidans are constituents of brown seaweed and showed already a wide variety of different effects, which can be useful for the treatment of ocular diseases like age related macular degeneration (AMD).

The exact effects of the fucoidan, however, depend on its molecular structure, origin, season and the cellular model system. We compared fucoidans from different seaweed species and their effects on ocular cells. With this pre-screening the best extracts for further tests can be chosen.

Methods: Brown algae (*Fucus vesiculosus, Fucus distichus subsp. evanescens, Fucus serratus, Laminaria digitata, Saccharina latissima*) were harvested and fucoidans isolated with hot water extraction. Several fucoidan concentrations (1, 10, 50 and 100 µg/ml) were tested. Effects were measured on uveal melanoma cell line (OMM-1), RPE cell line ARPE19 and primary RPE cells. Oxidative stress was induced by H2O2 or tert-Butylhydroperoxide (TBHP). Cell viability was investigated with MTT or MTS assay, VEGF secretion with ELISA. Affinity to VEGF was determined by a competitive binding assay.

Results: Several fucoidans protected OMM-1 from oxidative stress. However, in ARPE19, only fucoidan from Saccharina latissima was protective. But they don't interfere with the intracellular oxidative stress level. The affinity to VEGF of tested fucoidans was stronger than of heparin, and they reduced VEGF secretion in ARPE19. In primary RPE, fucoidan from Saccharina latissma was effective.
Conclusion: Among the fucoidans from the different seaweed species, Saccharina latissima displayed the most promising results concerning oxidative stress protection and reduction of VEGF secretion.

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ABSTRACT #15

MANIPULATING MACRONUTRIENT CONCENTRATION (N, P, Fe) TO ENSURE VEGETATIVE CULTIVATION OF KELP GAMETOPHYTES (*SACCHARINA LATISSIMA*) FOR THE AQUACULTURE INDUSTRY

SPEAKER

Maryam MacCorquodale
Scottish Association for Marine Science (SAMS), Oban, Scotland

Maryam MacCorquodale is a PhD student at Scottish Association for Marine Science (SAMS) working on Kelp gametophyte bioreactors for metabolite extraction. Her main research interest is in bioprospecting for novel bioactive compounds from marine environment. The focus of her current project is to optimise the methods for the cultivation of kelp gametophytes, examine their composition and identify novel bioactivity. Ultimately, increase the yield of compounds of interest by manipulating the culture conditions. Her previous work includes extraction of polysaccharide from a noble marine bacterium, also extraction of isoprenoid lipid (HBI) as biomarkers to study Arctic ecosystems.

European seaweed aquaculture requires reliable methods to produce high-volumes of kelp gametophytes as a seedstock. These can be maintained vegetatively in seedbanks for year-round access, negating the need for natural spore collection. Additionally, since kelps are a source of valuable bioactive compounds, these vegetative gametophyte could be an alternative source, reducing harvesting of natural beds. A number of abiotic factors influence growth and gametogenesis of gametophytes. The aim of this study was to identify the conditions that inhibits gametogenesis and maintains vegetative growth under white light. Oogenesis was studied through factorial experimental on the female gametophyte of Saccharina latissima. The effect of concentration of phosphate and nitrate in culture media and the ratio (N:P range: 4.5:1 – 60:1) was investigated over 35 days. In a separate experiment, the iron concentration in artificial seawater (GP2) was manipulated (range 0 -0.0117 mM) and availability of this iron modulated using the chelator EDTA.

All cultures remained vegetative under red light. Under white light cultures with Nitrate at concentrations above 1.8 mM remained vegetative, while increases in phosphate reduced oogenesis. The culture remained vegetative when iron was excluded from the culture medium. Additionally increases in concentration of the chelator EDTA reduced the oogenesis.

The manipulation of macronutrient concentrations is an effective method to allow vegetative cultivation of gametophytes under white light. Iron appears to be essential for gametogenesis. Depleting the medium iron concentration may be an effective method to maintain vegetative gametophyte cultures as a seedstock for seaweed aquaculture.

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ABSTRACT #16

THE UNKNOWN KELP FORESTS OF GREENLAND – THE EAST COAST'S UNEXPECTED LUSHNESS

SPEAKER

Susse Wegeberg
Department of Bioscience - Arctic Environment, Aarhus University Denmark

Senior advisor at Arctic Research Centre, Department of Bioscience / DCE - Danish Centre for Environment and Energy, Aarhus University. MSc and PhD from University of Copenhagen. SW has almost 20 years of experience within research and consultancy. SW takes part in and is the coordinator of the DCE consultancy regarding the environmental aspects of the oil exploration in Greenland, including regulation and monitoring Arctic ecosystems as well as the environmental aspects of oil spill response and technologies. SW has her key expertise within Arctic marine ecology and biodiversity, however, with strong focus on marine seaweed, and has been working with seaweed in Nordic countries, mainly Denmark and Greenland, for more than 20 years. This work comprises cultivation and commercial use of marine macroalgae as well as inter- and subtidal investigations of marine macroalgae communities in Greenland.

Until now, investigations of the intertidal and nearshore seaweed communities in East Greenland have been sparse. However, as part of a comprehensive environmental studies programme related to potential oil exploration activities, the aims of the present study were to add information on the seaweed biodiversity, coverage, and biomass for establishment of baseline, including evaluation of the coastal seaweed communities' sensitivity to oil spill, but also as a new marine resource.

The coastline from 65 N to 77 N was investigated by underwater video recordings in transects from app. 0 to 50 m depth using an underwater video camera. The videos were analysed for species specific coverage and depth limits. Samples were obtained by SCUBA divers and analysed for species specific biomass and associated fauna.

We will present the analysed data on the distinct seaweed communities that were observed; forest-like vegetation with dominance of kelp species, and seaweed meadows dominated by Fucus distichus and Chaetopteris plumosa. Kelp forests were present up to 76 N and further. Kelp forests consisted of Alaria esculenta, Laminaria solidungula and Saccharina latissima with red algal species, Coccotylus truncatus and Turnerella pennyi at greater depths. A hotspot for kelp forest was observed in the Tasiilaq-area (65 N), which included the typical West coast kelp forest element of Agarum clathratum.

No apparent change in kelp coverage along the south-north gradient of 12 latitude degrees was observed and kelp biomasses reached comparable weights as in the Cape Farewell area, South Greenland, however, ice seemed a complex and important driver.

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ABSTRACT #17

SEAWEED-BASED BIOETHANOL, ABE AND VALUE-ADDED PRODUCTS

SPEAKER

Anne-Belinda Bjerre
Danish Technological Institute, Denmark

Anne-Belinda Bjerre is the Scientific Manager at Danish technological Institute and the adjunct Professor at the Department of Biotechnology, Chemistry and Environmental Engineering of Aalborg University. She is a chemical engineer with Ph.D. in biotechnology. She is an expert in the field of chemical and biological processes for conversion and extraction of plant (residue) and seaweed biomass to bioenergy and value-added products. She has been coordinating several Danish and EU projects in the field of Seaweed Biorefinery e.g. MacroFuels, MacroCascade, SeaRefinery, MAB3, and MAB4.

Due to a still growing demand on energy and food supply, seaweed has gained more and more attention as feedstock for bio-energy carriers and value-added products. A novel biorefinery concept has been developed and tested in MacroFuels project. An overview will be presented from cultivation of brown seaweed, bioconversion of the algae sugar-polymer laminarin to bioethanol and acetone-butanol-ethanol (ABE), and testing the produced ethanol in a real test car.

Laminarin, one of the main storage carbohydrates in brown seaweed consisting of a ß-(1, 3) main glucan chain with small amounts of ß-(1, 6) glucan branches, can be extracted under mild conditions (e.g. hot water) from suitable brown seaweed species and afterwards efficiently be fermented to bioethanol and ABE (e.g. ethanol yield at about 80% theoretical yield and ethanol final titer up to 9 % were achieved, while ABE yield at 30% on consumed sugars were obtained). Pilot scale demonstration of bioethanol and ABE resulted in 9.4 L bioethanol (purity >91%, after final distillation) and 10 L of an AB mixture, respectively. The produced seaweed-based ethanol was recently tested at a concentration of 10% (wt/wt) blended with gasoline in real automobile engine in the test car, of which the result will be presented.

The gentle extraction of laminarin left behind a solid residue with all value-added components i.e. antioxidants, proteins, fucoidans, and alginates which can be further refined to increase the economic benefits. A developed step-wise extraction process for recovery of these value-added components will also be presented.

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ABSTRACT #18

INSIGHTS ON ASSESSING THE SUSTAINABILITY OF A SWEDISH SEAWEED INDUSTRY

SPEAKER

Jean-Baptiste Thomas
Water and Environmental Engineering in the department of Sustainable Development, Environmental Science and Engineering (SEED) at KTH, Stockholm, Sweden.

Jean-Baptiste's research involves assessing the sustainability of the seaweed industry that is developing in Sweden. His doctoral thesis, defended in June 2018 and contributing to the Seafarm project, includes a wide range of analytical methods including an Energy and Greenhouse Gas Systems Analysis, Life Cycle Analyses, a Public Perception Survey, a Geographic Information Systems based Multi-Criteria Analysis, and an economic Cost-Benefit Analysis, which together form a collection of insights on the sustainability of a burgeoning Swedish seaweed industry. He is now working on a Post-Doc at the division of Water and Environmental Engineering in the department of Sustainable Development, Environmental Science and Engineering (SEED) at KTH, Stockholm. The Post-Doc will allow him to continue topics covered in the thesis, with a focus on economic and environmental supply chain optimisation, while also looking at the potential of marine biomass to contribute to more circular Nitrogen and Phosphorus economies in Sweden.

As a part of the Seafarm project, this thesis aimed to provide an assessment of the sustainability of ongoing developments, most notably through the lenses of viability, environmental life cycle perspectives and potential of a future Swedish seaweed industry.

A strategy for assessing sustainability was developed with effectiveness in mind and anchored in a broad range of issues highlighted as knowledge gaps by stakeholders; a series of six studies resulted therefrom. Each study contributes insights regarding very specific aspects of the sustainability of a seaweed industry: on the viability of kelp biofuel, threats to viability in the form of potential public aversion to seaweed aquaculture, life cycle perspectives on the cultivation and preservation of seaweed biomass, on the scale and spatial potential of the industry on the West Coast, and finally, on the economic potential of this future industry.

This collection of insights contributes six strategic pieces to the vast and dynamic puzzle that is the sustainability of a burgeoning seaweed industry. Together they paint a picture of a viable Swedish seaweed industry with promising potential to contribute positively to the SDGs and key sustainability challenges of the coming decades.

Thesis available at http://kth.diva-portal.org/smash/get/diva2:1215011/FULLTEXT01.pdf

POSTERS:

Crude extracts of *Fucus distichus* subsp. evanescens fucoidan as new component for ocular well-being? Effects on retinal pigment epithelium cells and their implications for use in age-related macular degeneration	Kevin Rohwer, University of Kiel
Storage method governs protein quality of brown seaweed	Joao Trigo, Chalmers University of Technology
Laminarin extraction for high-value and low-value products production	Xiaoru Hou, Danish Technological Institute
Upscaling of seaweed ensiling	Nicolaj Ma, Danish Technological Institute
Cultivating *Palmaria palmata* (Dulse) in land-based salmon-RAS system water	Peter Søndergaard Schmedes, DTU Aqua
Organic large-scale production of sugar kelp (*Saccharina latissima*)	Teis Boderskov, Per Dolmer, Michael Bo Rasmussen, Annette Bruhn, Aarhus University.
Sustainable harvest of bladderwrack (*Fucus vesiculosus*)	Anna Sauermilch, Michael Bo Rasmussen, Annette Bruhn, Aarhus University
Characterization of alginate from the Ghanaian brown seaweeds Sargassum spp. and Padina spp.	Nanna Rhein-Knudsen, DTU
Fucoidans: Enzymatic Purification and Modification	Maria Dalgaard Mikkelsen, DTU
Physical and oxidative stability of omega-3 delivery emulsions added algae-based stabilizers from *Saccharina latissima*	Ditte Baun Hermund, DTU
Can ensiled sugar kelp be used as a methane mitigating ruminant feed?	Rajan Dhakal1, Silje Steinsund2, Harald Sveier2, Hanne H. Hansen1* 1Department of Veterinary and Animal Sciences, University of Copenhagen, Grønnegårdsvej 3, DK-1870 Frederiksberg C, Denmark; 2Ocean Forest A/S, Box 7600, NO-5020, Norway
Tang.nu	
Macrofuels -a H2020 project	

PRODUCTS PRESENTED AT POSTERSESSION:

Ocean Well (natural maritime cosmetics)
ProAqua AS (cultivation of macroalgae) / Audun Oddekalv
Havhøst (seaweed gardens)
EvaLou (textiles)
Prannie Rhatigan (cook book and tastes of Irish seaweed)
Nordisk tang (gourmet food)
Forlaget Epsilon (seaweed booklet)
Seaman Chips

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